to do much damage throughout this entire region, but that the greatest destruction occurred about 4 miles east of Clearmont, over a region of about 4 square miles, as indicated on the accompanying map. Mr. Brink states that at one point in this region the fall of hail was so heavy that a drift unprotected by any artificial means remained lying on the ground for four weeks after the storm, and this too at a season of the year when the soil had a comparatively high temperature. Mr. Brink, leaving Marysville, visited the region where the storm occurred, just four weeks after September 5, and secured several excellent photographs of the scene. Even at that time he found the people of the neighborhood gathering the hail for the purpose of making ice cream. Pieces of ice had been picked up at the time of the storm of a cylindrical form of about four inches long by about two and a half in diameter. We reproduce on Chart XVI, Fig. *a*, a photograph showing how complete had been the destruction of growing corn. The stalk seen in the photograph was quite mature, and is the only one left standing in a field of 80 acres. Had it not been for the hailstorm, this field would have yielded 60 bushels to the acre when harvested in the middle of September. The half tone, Chart XVI, Fig. *b*, shows the complete destruction of the foliage in a grove of young trees. Of course, the falling cakes of ice destroyed the roofs and even the sides of the houses, sometimes the north and sometimes the north and west sides at Clearmont; when its force was not sufficient to make a fresh hole through the boarding, the hail would generally, at least knock out the knot holes. The northern edge of the storm seems to have passed about ten miles north of Maryville; but 2 or 3 miles farther north a narrow strip of country also suffered severely; see Chart XVI. The statement that in some places the earth was covered to the depth of a foot, while everywhere it was white with ice, seems to justify the conclusion that there must have been an average depth of from 4 to 6 inches over the central region of, at least, 4 square miles in area.

THE TELEGRAPH SERVICE WITH THE WEST INDIES.

By J. H. ROBINSON, Chief of Division.

Daily telegraphic weather reports from the West Indies, Central and South America, and the Mexican Gulf Coast are now received at the Central Office of the Weather Bureau, i. e., from Nassau, Habana, Santiago de Cuba, Kingston, Santo Domingo, San Juan, St. Thomas, St. Kitts, Dominica, Martinique, Barbados, Trinidad, Curaçoa, Colon, Coatzacoalcos Vera Cruz, Tampico, and from Merida when the conditions are threatening. Daily reports are also received from Bermuda. For details as to routes of submarine cables over which reports are transmitted, see Chart XIII, showing points at which the cables connect with the land lines.

During the entire duration of the recent war with Spain daily weather reports were regularly received at the Central Office of the Weather Bureau from Habana. The observations were taken by the observers of the Spanish Meteorological Service for the Antilles, and were telegraphed by their operators to Key West, where they were retelegraphed to Washington. The submarine cable from Key West to Habana remained intact during the entire war, as did also the cable from Santiago de Cuba to Kingston, Jamaica. As the Key West–Habana cable had its outlet through the United States, it was not deemed wise to disturb it; the Santiago de Cuba–Jamaica cable, however, was grappled for, but not caught.

In connection with this article, perhaps it would be of interest to know that the Weather Bureau observers on the seacoast in many instances rendered efficient service to their country by reporting passing vessels, one of the most important being the arrival of the *Oregon* off Jupiter, Fla.

WEATHER TYPES AT HAVRE, MONT.

By C. W. LING, Observer, Weather Bureau (dated October 10, 1898).

I forward herewith a few generalizations relative to the marked pressure conditions that produce certain weather in this vicinity as deduced from a study of the daily weather maps for the past two years. The cause of the warm southwest chinook winds that prevail here is easily explained to visitors as due to mechanical or dynamic heating, and the old Japan current theory, still held by many, is easily obliterated. The conditions preceding cold waves, or colder weather, are very well marked and invariably produce the expected cold weather, with high northwest winds.

Chinook conditions.—A high over Wyoming and southern Idaho, with a low pressure over northern Montana, invariably brings to Havre a dynamic rise in temperature, i. e., a chinook wind in winter and a warmer spell of weather in summer, and accompanied by high southwest winds.

Cold wave conditions.—A low barometer over Wyoming, Utah, and southern Idaho, with high over northern Montana, Alberta, and Assiniboia, indicates intensely cold weather for Havre in winter and much cooler in summer. A high pressure area, with the low in Wyoming, by its vertical action, draws down intensely cold air from above (see journal of December 1 and 2, 1897, and of March 25, 26, 27, 1898). These conditions produce cold, high, northwest winds.

The summer type of weather conditions in Oregon, i. e., a high over Washington and Oregon with a low over the northern part of Montana and southern Alberta, indicates a warm spell for Havre and vicinity (see data July 13 to 17, 1898).

A falling barometer after a dry and warm spell of weather, barometer falling below the normal, with falling temperature, with the forecast for warm, indicates a heavy June or July rain in a day or two; also a cool atmospheric wave, followed by a warm wave (see thermograph sheet July 18 to 19, 1898, and the precipitation on those dates).

A low pressure area of 29.7, or lower, extending west to the coast and far south, indicates for Havre two or three days of rain or snow.

ANEROID BAROMETERS.

By C. F. MARVIN, Professor of Meteorology (dated November 8, 1898).

The unreliability of aneroid barometers when anything like accurate measures of pressure are required is almost proverbial. It is evident that much work remains to be done in order to ascertain the laws governing the irregular action of this most convenient and, in some cases, indispensable type of barometer. It will be still better if we can ascertain and eliminate the real causes of the anomalous behavior. The face reading of an aneroid even when not compensated for temperature is often thoughtlessly accepted with every confidence as to its infallibility, but it is pretty generally understood among the more critical observers that aneroids require to be frequently checked and verified by comparison with standards, and that a slow change goes on within them after they have been subjected to a considerable change in air pressure.

It may be stated that, broadly classified, the inherent errors of all aneroids are of two kinds. When the instrument is exposed over long periods to only such pressure changes as occur at any station at the earth's surface from day to day, its error will remain sensibly constant for a considerable period of time, but from time to time relatively large changes may and generally do take place in this error without any apparent cause and can not, therefore, be duly allowed for. The other inherent error is an effect connected with any considerable change in pressure. Suppose, for example, the pressure is changed in a short space of time from 30 to 25 inches; at the instant the pressure becomes stationary the index of the aneroid will show a certain reading, but instead of remaining stationary with the pressure, it continues moving slowly downward over the scale showing a lower and lower reading as time progresses. This after effect is called "creeping;" it is analogous to the slow change in the zero of a thermometer and varies greatly under different circumstances and has been observed to increase during several days or even weeks. Its amount in a given barometer depends among other things upon how much and how rapidly the pressure has changed and whether the change was continuous or not. Finally, if the pressure is restored to its initial value, the index will fail to return immediately to the original reading, but will slowly creep toward it. These errors are separate and distinct from errors of graduation, or the effects of temperature and friction, or those depending upon what position is given the aneroid, all of which latter can be more or less perfectly disposed of. From the foregoing it necessarily follows that the readings carried up and down mountains or sent up with kites and balloons are subject to a series of errors which it is practically impossible to determine with any degree of exactness.

A most valuable series of experiments upon the aneroid has been published by Dr. C. Chree, Superintendent of Kew Observatory, whose paper on this subject, entitled Experiments on Aneroid Barometers at Kew Observatory and their Discussion, has recently appeared in Philosophical Transactions, Series A, vol. 195, 1895. The author's object, as he states, is "to acquire knowledge likely to increase the usefulness of the aneroid under the conditions in which it is actually employed."

In the execution of this object the tests of hundreds of aneroids, made during many years for the makers, at the Kew Observatory, were exhaustively discussed and other special tests were made to develop the law of the after effect or *creep*. Dr. Chree's analysis is most comprehensive and complete, and leaves little to be desired, but in the present writer's estimation, the fair conclusion to be drawn from the investigation is that the errors of all ordinary aneroid barometers are hopelessly involved in a complex law, so that under the complex conditions of use it is impossible, or at least impracticable to satisfactorily predict or determine the errors of a given instrument. Among other writers on this question may be mentioned Lovering, Proceedings American Academy of Sciences, 1849, Vol. II; also American Journal of Science, 2d Series, Vol. IX, p. 249: Balfour Stewart, B. A., Report, 1867; also Proceedings Royal Society, Vol. XVI, 1869; Philosophical Magazine, Vol. XXXVII, 1869: Whymper, How to Use the Aneroid, John Murray, 1891, and Carl Barus, American Journal of Science, Vol. I, 4th series, 1896.

Lovering, Stewart, and Whymper may be said to have observed and recorded the facts relative to the errors of aneroids. Dr. Chree has gone a step further and formulated the approximate law of error. Unfortunately this law appears to be too complex and involved to become practically useful. What still remains to be done is to definitely ascertain the cause of the difficulty, and if this can not be quite largely eliminated by an improved construction we must then invent some new and better type of instrument. A step in this direction has been taken by Prof. Carl Barus, whose countertwisted curl aneroid, he claims, is practically free from the after effect and similar errors common to other forms of aneroid. The experimental forms investigated by Professor Barus are very delicate pieces of laboratory apparatus, and are scarcely available for practical work. The "countertwisting" is, however, a new feature, and may yet prove to be of great value in practical instruments.

The present writer has given some thought to this problem from time to time, but no opportunity has been offered for making any new investigations. It seemed to me that the real seat of the greater part, if not all of the after effect or creeping, is in the corrugated aneroid vacuum boxes themselves, as distinguished from the tempered steel springs that are employed to keep the box from collapsing under the pressure of the air. This conviction was forced upon my mind after reading Mr. Whymper's valuable paper on the errors of the aneroid, and in 1892 I made the following simple experiment, which greatly confirmed this supposition: The vacuum box of an old aneroid was removed, and a heavy weight (a trifle over 50 pounds was required) was applied directly to the steel spring, thereby straining it as nearly as possible to the same extent as did the air pressure exerted through the medium of the corrugated vacuum box. Any desired changes in the position of the index were made by appropriate changes in the weight. No after effect comparable in magnitude with that exhibited by ordinary aneroids was ever observed. In other words this tempered steel spring behaved to all intents and purposes as if it were a *perfectly* elastic body. Readings of the pressure scale could be made corresponding to about 0.005 of an inch on the barometer. A careful or full investigation was not attempted. I believe nevertheless that the tempered steel springs employed in all aneroids are or may easily be made to be highly trustworthy. On the other hand the process of constructing the vacuum boxes is well calculated to develop therein irregular and imperfect elastic properties in the highest degree. The top and bottom surfaces are each formed of a thin circular sheet of metal, with a narrow rim bent up around the edge. In order to give flexibility several concentric corrugations are formed over quite the whole face of the disk. The crimping and bending operations necessary in the manufacture of these corrugated disks have a marked effect upon the elastic qualities of the metal, which to make matters worse is generally of brass, german silver, or some similar alloy well known to be only imperfectly elastic under the most favorable conditions. The metal must originally be, more or less, in a soft and annealed condition in order to withstand the corrugating and bending operations. Those portions which are stretched and compressed by the process become stiffer and more elastic, and the finished disk is permeated by a most complex and irregular system of internal strains. The arrangement of molecules is undoubtedly a highly unstable one, and it is not surprising that large, discontinuous, and unexpected changes take place in the readings of the finished instrument.

In 1896 I had occasion to design a meteorograph suitable for use on the kites recently employed by the Weather Bureau in making aerial observations. The lightest possible form of barometer of the aneroid type was an obvious necessity. The considerations outlined above led me to substitute steel in place of brass for the vacuum boxes, and a preliminary effort was made to profit if possible by the results brought out by Professor Barus. Mechanical difficulties in securing a satisfactory form of recording aneroid on these lines forced me however to abandon this attempt at the time and adopt a type of instrument similar to the well known Richard barograph. The vacuum boxes were made of steel instead of composition metal. The performance of these barometers, although better generally than brass instruments, has disappointed my expectations, as they have exhibited considerable after effect, which I am still convinced is due primarily and largely to the imperfect elastic properties of the boxes themselves. Boxes of small diameter were necessarily adopted, but these are inferior to those of large diameter. In support of this statement I find a very significant note in Dr. Chree's paper, p. 446, stating that the after effect in 30 barometers of special make and large size (how large is not stated) as tested at Kew, was so exceptionally small that he found it necessary to multiply the actually observed effects by seven in order to make the figures similar in size to corresponding results from ordinary aneroids.

In concluding these remarks attention is called to a certain source of error in testing aneroids that does not appear to have been mentioned hitherto, and if not noticed or guarded against may have an appreciable effect on results. Any sudden change in the air pressure under the receiver of a pump inevitably heats or cools the gas dynamically, in consequence of which there is a most pronounced and real "after effect" in the pressure of the air within the receiver. In my own experience I have been very greatly surprised at the slowness with which the gas acquires its stationary temperature and the magnitude of this effect on the resulting stationary pressure. The slow rate of pressure change adopted by Dr. Chree, namely, one inch in five minutes, in all probability eliminates any error of this kind, but the point is not mentioned, and it is just possible that the results of the older observations and of investigations made without due regard for this effect may be somewhat in error in consequence.

NOTES BY THE EDITOR.

THE OMAHA CONVENTION OF WEATHER BUREAU OFFICIALS.

On several previous occasions conventions of Section Directors of State Weather Services have been held, to the great advantage of the individuals and the Service, and it was, undoubtedly, a wise innovation when the Chief of the Weather Bureau decided to expand this idea and call for a general convention of Weather Bureau officials of every grade. The convention was of a thoroughly cosmopolitan character, every section of the country was represented, and every class of men. There was a large sprinkling of voluntary observers, an encouraging number of the younger employees, and several of the oldest and most venerable. Three men were present from the class of 1871, but the classes that were most prominently in evidence were those of 1881–83. The official report will show that the long programme was attacked and faithfully followed up, although the work had to be done too rapidly for comfort, owing to the loss of a day. The photograph of the group of seventy members remains as a visible embodiment of the fraternal intercourse, the social pleasures, and the intellectual profit of a meeting that will always remain vividly impressed upon the memories of all who were present as one of the most delightful events of official life. If it were not for the expense we are sure that every one would attend such a convention every year. Many inquiries were made for those who could not be present; both we and they lost much by their absence. The enthusiasm of all who took part in the discussions was remarkable; every one had some positive results of his own local experience to communicate for the benefit of the others. The diversity of ideas impressed one with the conviction that everywhere the work of the Weather Bureau is being adapted to special local conditions and that a hard and fast rule for the whole country would, oftentimes, work inconvenience or injury. One learned not to be so intolerant of the views of others and so positive that his own ideas will suffice for all occasions. The new devices submitted by Townsend of Philadelphia and Sims of Albany at their own expense and the new principle in meteorology brought forward by Hammon of San Francisco excited deep interest.

By its rather early adjournment the convention, unfortunately, missed the telegram inviting us to a special excursion to Lincoln, Nebr., where we should have inspected the relations of the Service to the State University. May we be more fortunate next time! In a few cases some general expression of opinion was uttered by the convention but, as a whole, the sentiment that pervaded it seemed to be to the effect that no business, properly so-called, need be transacted, as we were brought together at the call of the Chief to confer with him. Consequently, no vote was taken as to the time and place of the next meeting, that being a matter that can be left with Professor Moore; nevertheless, a hearty acclamation followed the pleasant rivalry between Hammon and Pague in advocacy of San Francisco, Cal., and Portland, Oreg., respectively. On the whole, the general conclusion must be that such conventions are essential to the welfare and strength of our meteorological service. Scattered as we are, widely over the whole country, we get but little opportunity for personal intercourse, we pursue our studies alone and with difficulty, little items of daily practice and of meteorological theory that would be quickly settled by conference with some neighboring observer, give us unnecessary trouble. The annual convention is a clearing-house, where we may balance accounts, discuss ideas, settle perplexities, dissipate the troubles of official life, burn our bridges, and take a new start.

THE WEATHER AND THE SUGAR CROP.

In the MONTHLY WEATHER REVIEW for August, 1897, page 354, we have given the general relation between annual rainfalls and sugar crops in the Island of Mauritius for the years 1880 to 1895, as quoted from the annual report of the Royal Alfred Observatory for the year 1895, by Mr. F. F. Claxton, who is now the director succeeding Dr. Meldrum who resigned September 30, 1896, on account of failing health, after a term of twenty-two years in the service. Since that date the reports for 1896 and 1897 have been received, from which we extract the following table showing the relation between the annual sugar crop of the whole island and the rainfall. The sugar crop is the result of the growth of the previous fifteen or eighteen months, beginning with the planting in September of the second year previous. The following table gives the total rainfall for those months during which the cane of the respective crops has been growing. It is an average for four stations, viz, Pamplemousses, Gros Bois, Cluny, and Union Bel-Air, which fairly represent the sugar districts:

Years of harvest.	Total sugar crop.	Rainfall during growth.
	Kilograms.	*Inches.*
1880	119,731,492	68.39
1881	117,809,610	78.68
1882	116,719,997	118.37
1883	120,396,858	84.03
1884	127,784,339	75.55
1885	115,299,030	77.13
1886	102,376,271	57.25
1887	124,073,140	86.18
1888	132,172,988	125.40
1889	124,564,951	108.71
1890	130,220,273	88.94
1891	113,813,075	96.61
1892*	68,718,573	98.78
1893	139,751,810	80.39
1894	113,793,319	88.11
1895	142,645,722	96.11
1896	152,677,973	108.58

* Destructive hurricane.

For the crop of 1897 the corresponding rainfall was the lowest on record, and in fact, scarcely one-half of the normal amount, and the sugar crop was exceedingly poor; but the exact figures are not at hand to be inserted in the above table. If we rearrange the above figures in the order of the